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Nr. 10. C. H. Ostenfeld: A REVISION OF THE MARINE SPECIES OF CHÆTOCERAS EHBG. SECT. SIMPLICIA OSTF. WITH 24 FIGURES IN THE TEXT

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KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1912

MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER
SERIE: PLANKTON · BIND I · NR. 10 · 1912

A REVISION

OF THE

MARINE SPECIES OF

CHÆTOCERAS EHBG. SECT. SIMPLICIA OSTF.

BY

C. H. OSTENFELD

WITH 24 FIGURES IN THE TEXT

KØBENHAVN
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Among the plankton diatoms the genus *Chætoceras* has by far the most species, and the limitation of these has been rather a difficult task. Nevertheless, the northern species are now fairly well characterised and delimited with exception of those belonging to the section *Simplicia* Ostf.

Gran[1] has divided the genus into two subgenera *Phæoceras* and *Hyalochæte* distinguished mainly by the presence or absence of chromatophores in the setæ. It is a very natural and as a rule easily seen distinction which has been used by all later investigators. It was therefore a retrograde step when Lemmermann[2] tried to give a revision of the solitary-living species without taking Gran's subgeneric distinctions into consideration. His treatment is on the whole not a happy one. Many of the species which he deals with, belong to subgen. *Phæoceras*, viz.: *Ch. radiculum* Castr., *Ch. peruvianum* Btw., *Ch. saltans* Cleve, *Ch. danicum* Cleve, *Ch. æquatoriale* Cleve, *Ch. volans* Schütt [= *C. criophilum* Castr., *f. volans* (Schütt) Gran], *Ch. currens* Cleve [= the preceding], *Ch. audax* Schütt [= *C. atlanticum* Cleve, f. *audax* (Schütt) Gran], *Ch. curvatum* Castr., and hardly any of them is truly solitary, but several of them are the initial cells of chain-forming species. They must naturally be placed among other species in the two sections af *Phæoceras*, viz. *Atlantica* et *Borealia*[3].

With regard to the remainder of Lemmermann's *"Solitaria"* the matter is different; they[4] belong to but one section of the subgenus *Hyalochæte*, a section which I have named *Simplicia*. All are small, faintly siliceous species the cells of which occur solitary or two together. They have 1—2 chromatophores and very thin setæ; resting spores are found in several of them and probably occur in all. As to their habits they are markedly neritic, having their home in shallow coast-waters or in lagoons. Some of them also occur in freshwater. The distinction between the species is difficult, and several of them have been unsatisfactorily described, thus giving great trouble to later investigators.

As I have taken a great deal of interest in these species and have had access to most of them myself and often the original samples from where they were described, I shall in the following try to arrange them in a more thorough manner. The freshwater species I have not seen and leave out of consideration; Lemmermann[5] has described one: *Ch. Mülleri*, and Honigmann[6] several.

1. Chætoceras distinguendum Lemmermann, Ark. f. Botanik, Stockholm, Bd. 2, No. 2, p. 137, 1904; *Ch. clavigera* Ostenfeld, Bot. Tids., København, Bd. 25, 1902, p. 234, fig. 11.

Non: *Ch.(?)clavigerus* Grunow, Denkschr. Math.-naturw. Classe d. k. Akad. d. Wiss., Wien, 1884, p. 96, pl. E, fig. 51.

[1] H. H. Gran: Protophyta, in the Norwegian North-Atlantic Expedition 1876—78. Christiania 1897.

[2] E. Lemmermann: Das Plankton Schwedischer Gewässer. — Arkiv f. Botanik, Bd. 2, No. 2. 1904.

[3] In 1903 I have subdivided the two subgenera into several smaller divisions (Botany of the Færöes, vol. II. Copenh. 1903).

[4] Lemmermann (l. c. p. 141) enumerates also *C. incurvum*, var. *umbonatum* Castr. among the solitary species, but it is only the resting spore of a species, probably *C. scolopendra* Cleve.

[5] Forschungsber. biol. Stat. Plön, VI, 1898.

[6] H. Honigmann, in Archiv f. Hydrobiologie u. Planktonkunde, Bd. V. 1909.

Cells solitary or two together, 8—10μ broad, in side (pleura) view rectangular with rather straight contours, in valvar view elliptic. Setæ nearly perpendicular upon the cell in side view, those of the one valve shorter and more clavate than those of the other; the thickened distal parts of the setæ with twisted striations and short spines. Chromatophore single, in front. Resting spores unknown.

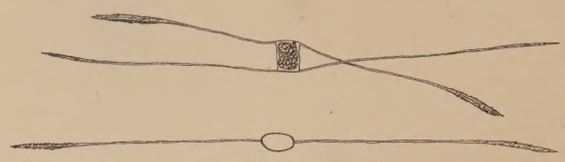

Fig. 1. *Chætoceras distinguendum* Lemm. ($^{450}/_{1}$). (From Ostenfeld 1902).

Geogr. area: Gulf of Siam (near Koh Chang).

As LEMMERMANN (l. c.) pointed out, my name cannot stand, because GRUNOW has used it for a fragment of a siliceous body which may perhaps be the seta of a *Chætoceras*.

2. Chætoceras simplex Ostenfeld, Vidensk. Medd. Naturh. Forening, København 1901, p. 137, fig. 8; Pavillard, Recherches s. la Flore pélagique de l'Étang de Thau, Montpellier, 1905, p. 72, pl. 2, fig. 6, 7; O. Paulsen, Medd. Komm. Havundersøg., Serie Plankton, vol. 1, No. 3, København 1905, p. 6, figs. 8—10;

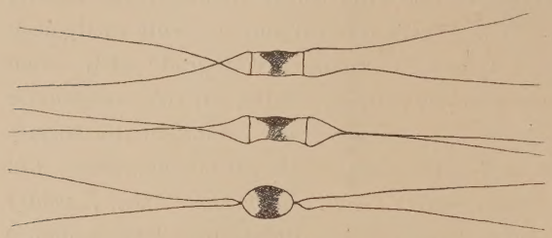

Fig. 2. *Chætoceras simplex* Ostf. from the Caspian Sea. ($^{450}/_{1}$) (From Ostenfeld 1901).

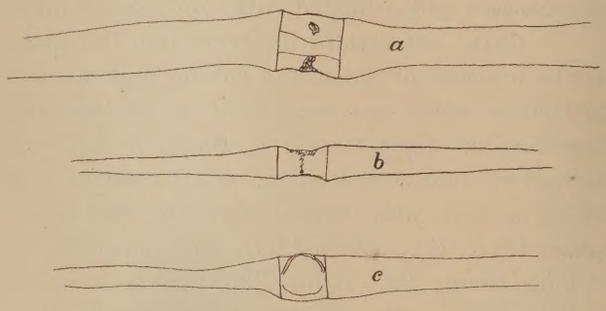

Fig. 3. *Chætoceras simplex* Ostf. from the Caspian Sea. ($^{450}/_{1}$) (From Paulsen 1905).

Ch. subsalsum Lemmermann, Ark. for Botanik, Bd. 2, Nr. 2, 1904, p. 141, pl. 1, fig. 16; ? *Ch. Borgei* Lemmermann, ibidem, p. 143, pl. 1, fig. 17.

Cells solitary or two together, 6—16μ broad[1], in side view rectangular with more or less undulate valvar contours, in valvar view broadly elliptic. Valves faintly concave with a slight elevation in the

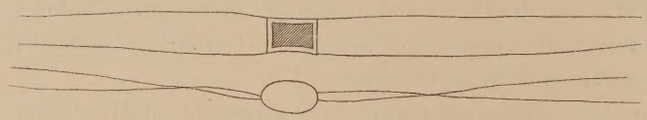

Fig. 4. *Chætoceras simplex* Ostf. from Étang de Thau. (From Pavillard 1905).

Fig. 5. *Chætoceras simplex* Ostf. (*Ch. subsalsum* Lemm.) from Upland. (From Lemmermann 1904).

middle. Setæ nearly perpendicular upon the cell in side view, mostly more or less arched in the proximal part, otherwise nearly parallel or slightly converging or diverging in the distal part, thin and delicate. Chromatophores 1—2, placed either in front or on the valves. Resting spores nearly globular, more or less armed with small and short spines or papillæ.

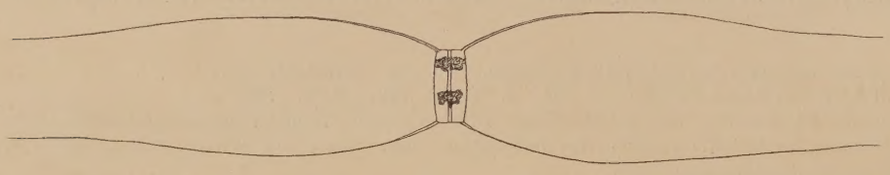

Fig. 7. *Chætoceras simplex* Ostf.? (*Ch. Borgei* Lemm.) from Upland. (From Lemmermann 1904).

Geogr. area: Caspian Sea [Ostenfeld], Étang de Thau in the Gulf of Lions [Pavillard] (Fig. 4), fjords of North- and East-Iceland [Paulsen], lagoon of the

[1] In my paper of 1901 it is said "—24μ" wheich is a printing error for 14μ.

Baltic in Upland, Sweden [Lemmermann], harbour basin at Frederikshavn, Jutland [Ostenfeld], rarely and in single specimens in Kattegat and Baltic (off. Gjedser) [Internat. Plankton Catalogue].

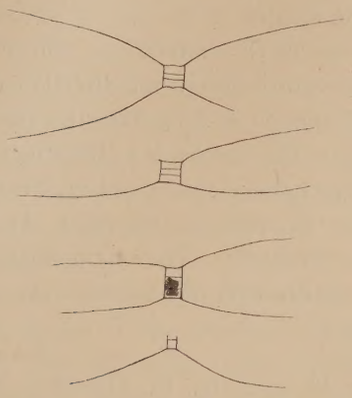

Fig. 6. *Chætoceras simplex* Ostf. from Upland. ($^{400}/_{1}$)

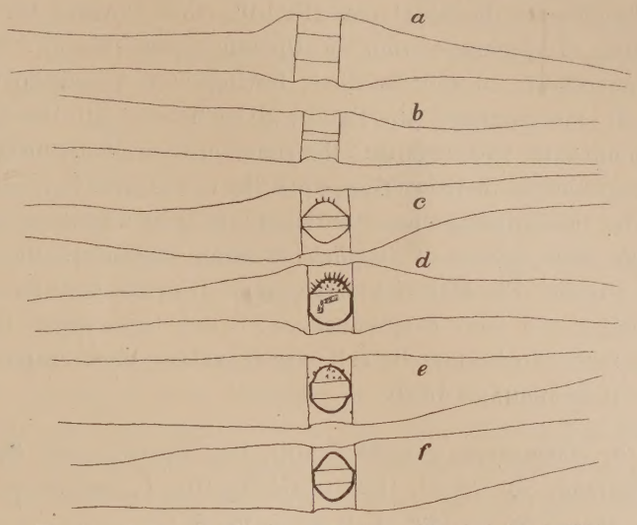

Fig. 8. *Chætoceras simplex* Ostf. from Øfjord, Iceland ($^{460}/_{1}$) (From Paulsen 1905).

This species which I have described from the Caspian Sea (Figs. 2, 3) has proved to have a wide distribution; it seldom occurs in the open sea, but only in bays and lagoons, where it is often present in large numbers. It is very delicate and easily overlooked. Owing to its smallness it passes through the meshes of the ordinary plankton-nets, if other organisms are not so numerous as to stop up the meshes.

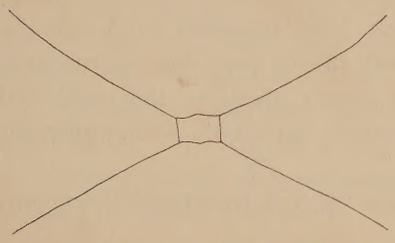

Fig. 9. *Chætoceras simplex* Ostf., var. *calcitrans* Paulsen from Iceland ($^{460}/_{1}$) (From Paulsen 1905).

It seems to be a summer and autumn species recorded from July to October in its different localities.

I take it for certain that LEMMERMANN's *Ch. subsalsum* (Fig. 5) belongs here. I have had the sample from which his description was drawn for examination through the kindness of Professor LINDMAN of Stockholm, and the species I found there agrees in most characters with *Ch. simplex*, as may be seen from the drawings given here (Fig. 6). In the same sample LEMMERMANN has found another species *Ch. Borgei*, of which he (l. c.) gives a description and a figure (Fig. 7). I have not succeeded in finding it in the material, but I have seen specimens of *Ch. simplex* with elongated cells and two chromatophores which strongly resemble LEMMERMANN's figure. His drawing of the hoop is different, — and consequently the whole cell has to be turned 90°. I have copied his figures to show how near his two species are to each other, if we only arranged them in such a manner that the setæ have the same direction. I cannot but suspect that his *Ch. Borgei* is a large specimen of *Ch. simplex* with elongated cells and beginning division, — thus having two chromatophores.

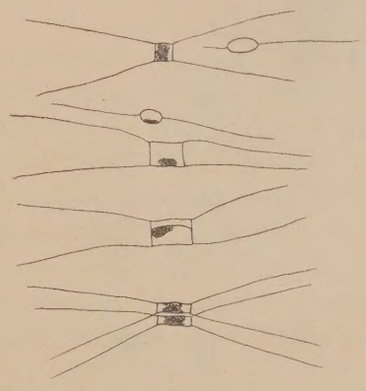

Fig. 10. *Chætoceras simplex* Ostf. from the harbour of Frederikshavn, Jutland. ($^{400}/_{1}$)

PAULSEN has found *Ch. simplex* in the fjords of Iceland and has given a series af drawings from that area, they are copied here (Fig. 8); he has found the resting spores. A somewhat aberrant form also occurs, which has the setæ not parallel, but diverging in an acute angle; he has named it var.

calcitrans (Fig. 9); I think I have found the same in the harbour basin of Frederikshavn in Jutland (17 July 1909) where *Ch. simplex* was common and where its setæ were rather varying with regard to their direction in the distal part (Fig. 10), thus showing that this character has to be used with caution. My figures of specimens from the Upland lagoon (Fig. 6) differ also in that respect somewhat from those of Lemmermann, in spite of their having been based upon the same sample.

If one compares the figures given here — all the known figures of *Ch. simplex* —, one finds a great conformity with regard to the shape of the cells themselves and some variation in the direction of the setæ, nevertheless their insertion upon the cell is always nearly perpendicular to its long axis, the two setæ of a valve thus forming a nearly straight line or at least a very obtuse angle. The species is well distinguished from the other species af *Simplicia* by those characters, only *Ch. distinguendum* being closely related to it.

Further *Ch. Mülleri* Lemmermann (Forsch.-Ber. biol. Stat. Plön, VI, 1898, p. 195, fig. 1–2) seems to belong to the same neighbourhood; it has been found in a lake in Holstein. The main distinctive feature seems to be that its cells are in valvar view "rundlich oder quadratisch mit konvex verbogenen Seiten" (Lemmermann 1898).

3. Chætoceras gracile Schütt, Ber. Deutsch. bot. Ges. 1895, p. 42, pl. 5, fig. 13; Ostenfeld, Medd. om Grønland, vol. XLIII, 1910, p. 277, fig. 10; *C. septentrionale* Cleve, Bih. K. Svenska Vet. Akad. Handl., Bd. 22, afd. 3, No. 4, 1896, p. 9, pl. 2, fig. 8.

Non: *C. gracile* Paulsen, Medd. Komm. Havundersøgelser, Plankton, vol. I, No. 3, København, 1905, p. 5, figs. 6—7; Apstein, Wiss. Meeresunters., Abt. Kiel, N. F., Bd. 11, 1909, p. 135, fig. 1; *C. septentrionale* Östrup, Medd. om Grønland, vol. XVIII, 1895, p. 457, pl. 7, fig. 88.

Cells solitary, 6—10μ broad, valves in side view concave, in valvar view elliptic or round-elliptic; setæ in sagittal plane, emerging from a little within the corner of the valve, their proximal parts strongly but not abruptly curved, the distal ones nearly perpendicular upon the cell in side view and approaching to be parallel to one another; chromatophores two sagittal; resting spores about in the middle of the mother-cells, lenticular to nearly globular, valves nearly uniform, convex and both with numerous small spines.

Geogr. area: Baltic Sea [Schütt]; Baffins Bay [Cleve]; Greenland Sea, off. N.E. Greenland [Ostenfeld]; ? Polar Ocean [Gran].

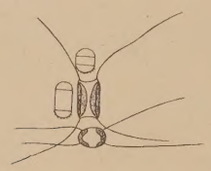

Fig. 11. *Chætoceras gracile* Schütt, from the Baltic. (From Schütt 1895).

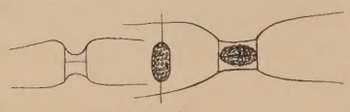

Fig. 12. *Chætoceras gracile* Schütt (*Ch. septentrionale* Cleve), from Baffins Bay. ($^{500}/_{1}$). (From Cleve 1896).

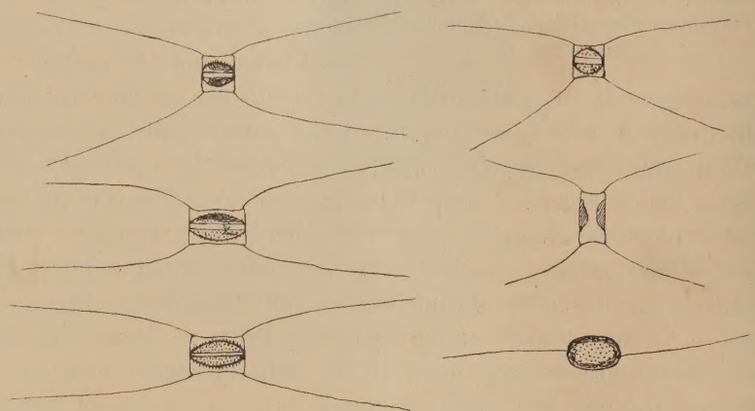

Fig. 13. *Chætoceras gracile* Schütt, from Danmarks Havn, N. E. Greenland. ($^{500}/_{1}$) (From Ostenfeld 1910).

In 1895 F. Schütt (l. c.) described a solitary species of *Chætoceras* from the Baltic under the name *C. gracile* and gave a minute figure of it (see Fig. 11), — a figure which did not quite answer to the description. In the same year E. Östrup (l. c.) described his *C. septentrionale*, a species which was found

solitary or in pairs in lumps of diatoms from the ice-floes off East-Greenland; his figures (Fig. 14) were drawn from ignited material and are not very perfect. Owing to the defective figures and our insufficient knowledge these two species, which are nearly related, have caused much confusion, and I must admit that the matter is not yet wholly cleared up. The material upon which Östrup created his species has afterwards been carefully examined by O. Paulsen (l. c.) to whom we owe better figures and descriptions (see Fig. 15), and I have myself later reexamined it. On the other hand I have not succeeded in obtaining more detailed information about *C. gracile* Schütt; I have asked for this several times from the author, but without result. Thus, we are forced to use his description and his figures, and where the first differs from the latter, to keep to the words; e. g. he describes both the valves of the resting spores as "rauh bis kurz bedornt", while his figures — in which the spores are drawn without any connexion with vegetative cells and perhaps do not belong to the same species as these — show one valve smooth, the other with short spines.

A year later P. T. Cleve (l. c.) published a description and figures of a solitary species found with resting spores in the plankton of Baffins Bay (in August) and identified it with Östrup's species. His figures (Fig. 12) differ rather much from those given by Östrup. It is very characteristic that the setæ in Östrup's figures are twisted and curved in all directions, so much that they cross each other; they seem to be very flexible. In Cleve's figure the setæ diverge from the cell in a rather regular manner, viz.: their proximal parts are strongly curved, so that their distal parts which are straight run nearly perpendicular to the cell in side view and approach to be parallel among themselves. The shape of the cell is about the same in both cases, and nothing is said by any of the authors about the contents (chromatophores etc.). On the other hand, if we compare Cleve's figures with those given by Schütt of his *C. gracile*, we find a much closer resemblance, and later authors correctly have identified the two species [e. g. Gran, in Nordisches Plankton, 1905]; a further argument for uniting them was found recently by the present author while studying plankton-samples from North-East Greenland, viz.: the cell contains two sagittally placed chromatophores, just as Schütt has drawn them in his Baltic species (see Fig. 13). The finding places — Greenland Sea and Baffins Bay on the one side, the Baltic Sea on the other — seem at first glance rather extraordinary, but it must be remembered that the Baltic Sea harbours a number of arctic forms (relicts). In my opinion there is no doubt that the species found by Cleve and myself in the Greenland waters has to be united with Schütt's Baltic species and to bear the name *C. gracile*.

But with regard to the original *C. septentrionale* Östrup the matter is different. We know only the vegetative cells of this form, but they differ much from those of the true *C. gracile*, and therefore I think it is better, at least at present, to keep Östrup's form separate; through the examination of the original material by Paulsen and through the recent paper by A. Meunier we know a little more about it.

The species which Apstein (1909) has identified with *C. gracile* is another (*C. ceratosporum*) which well be treated later on. It is remarkable that *C. gracile* has not been refound in the Baltic Sea since Schütt discovered it, while the species which Apstein takes as *C. gracile* seems to be common there; but if we have to use Schütt's name at all, we must rely upon his words and drawings and are not allowed to transfer his name to another species which differs in essential points from his.

4. Chætoceras septentrionale Östrup, Medd. om Grønland, XVIII, 1895, p. 457, pl. 7, fig 88; *C. gracile* Paulsen, Medd. Komm. Havundersøg., Plankton, vol. I, No. 3. 1905, p. 5, fig. 6; *C. glaciale* A. Meunier, Microplankton, in Duc d'Orleans: Campagne arctique de 1907, Bruxelles 1910 (1911?) p. 251, pl. XXVII, figs. 38—44.

Non: *C. septentrionale* Cleve, l. c. 1896; *C. gracile* Schütt, l. c., 1895.

Cells solitary or two together, 4—8μ broad, mostly longer than broad; valves in side view concave

with very prominent corners, in valvar view round-elliptic; setæ emerging from the somewhat contracted corners, their proximal parts strongly curved, their distal parts irregularly bent and twisted, flexible, pointing in all directions; chromatophore one (?); resting spores unknown.

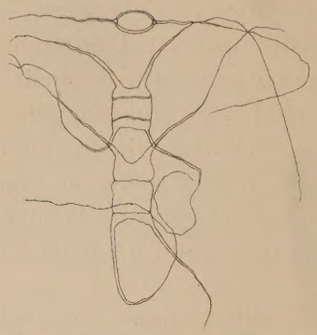

Fig. 14. *Chætoceras septentrionale* Östrup, from N. E. Greenland. (From Östrup 1895).

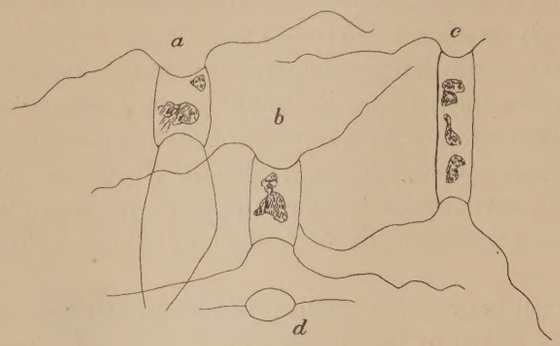

Fig. 15. *Chætoceras septentrionale* Östrup, from N. E. Greenland. ($^{1000}/_{1}$) (From Paulsen 1905).

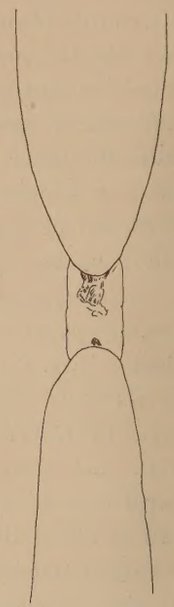

Fig. 17. *Chætoceras* sp. (*Ch. gracile,* var. Paulsen), from North Iceland. ($^{1000}/_{1}$) (From Paulsen 1905)

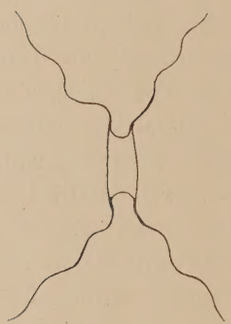

Fig. 18. *Chætoceras ceratosporum* Ostf.? (*Ch. tortilisetum* Mangin). (From Mangin 1910).

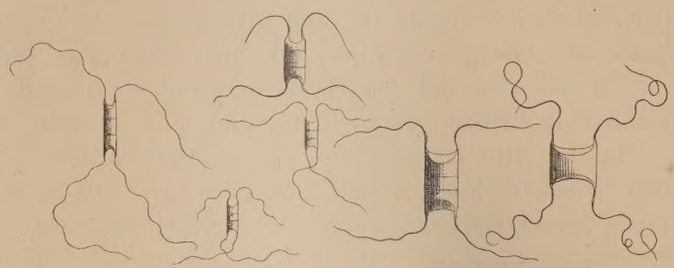

Fig. 16. *Chætoceras septentrionale* Östrup (*Ch. glaciale* Meunier), from Kara Sea. (From Meunier 1910).

Geogr. area: Among other diatoms in the ice-floes, often in great quantities, off East-Greenland [Östrup], Kara and Barent Seas [Meunier].

As mentioned above I think it better to keep the peculiar *Chætoceras* of the ice-floes of the arctic ocean separate and then it must bear the earliest name, that given by Östrup (l. c.). It is mainly upon the remarkable twisted setæ that the species is to be distinguished, as our knowledge of its other characters is so limited. According to Paulsen the cell-contents are irregular lumps, and I have seen the same when reexamining some of Östrup's material. I give copies of both Östrup's and Paulsen's drawings (Figs. 14, 15); and if we compare them with the recently published species *C. glaciale* Meunier, it will be evident that we have here the same species in a better condition. Meunier's drawings (Fig. 16) show that the setæ are very much bent, sometimes coiled, in their distal parts.

Perhaps later investigations will show that the form in question is only an aberrant state of *C. gracile* due to the peculiar conditions of life; the variations of the species next to be treated seem to point in that direction. But with our present knowledge it seems to me not allowable to unite them.

Mangin (Bull. Soc. bot. de France, t. 57, 1910, p. 345, fig. 1) has recently described a solitary species *C. tortilisetum* Mangin, which may perhaps belong to *C. septentrionale* Östr., as Pavillard (ibid.. t. 58, 1911, p. 24) has suggested, but more probably it belongs to the following species. As the description is very short and the drawing (Fig. 18) represents only one cell, it is not possible to settle the question definitely.

Nor can I decide where we have to place the form which Paulsen (l. c., fig. 7) has found at the north and west coast of Iceland, and which he unites with *C. septentrionale* (see Fig. 17). It seems to me to be a separate species which must be more closely examined.

5. Chætoceras ceratosporum Ostenfeld, Medd. om Grønland, vol. XLIII, 1910, p. 278; *C. gracile* Apstein, Wiss. Meeresunters., Abt. Kiel, N. F., Bd. 11, 1909, p. 135, fig. 1; ? *C. tortilisetus* Mangin, Bull. soc. bot. de France, vol. 57, 1910, p. 345, fig. 1.

Non: *C. gracile* Schütt, l. c. 1895; *C. gracile* Paulsen, l. c. 1905.

Cells solitary (or two together), 4—20μ broad, mostly as long as broad; valves in side view concave with prominent corners, in valvar view elliptic to round-elliptic; setæ emerging from the hardly or slightly contracted corners, their proximal parts more or less strongly curved, their distal parts mostly straight,

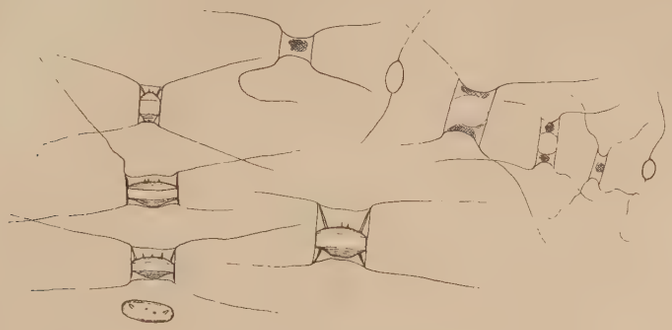

Fig. 19. *Chætoceras ceratosporum* Ostf., from the Baltic Sea, off Rødvig on Sjælland. ($^{400}/_{1}$)

Fig. 20. *Chætoceras ceratosporum* Ostf., from the Belt Sea, off Lyø. ($^{400}/_{1}$)

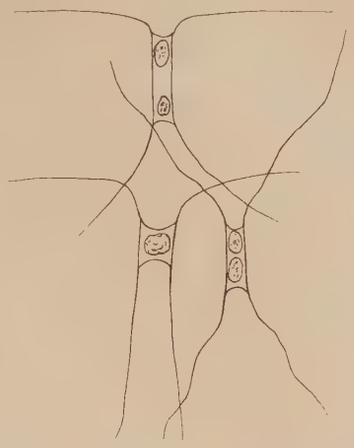

Fig. 22. *Chætoceras ceratosporum* Ostf., (*Ch. gracile* Apstein), from the Baltic Sea. (ca. $^{800}/_{1}$) (From Apstein 1909).

Fig. 21. *Chætoceras ceratosporum* Ostf., from the inner Baltic Sea, off Åland Islands. ($^{400}/_{1}$)

but in small specimens more or less twisted, diverging, rarely nearly parallel; chromatophore one, in front. Resting spores somewhat closer to the one valve; their primary valve convex with two larger hollow spines near the margin and sometimes several small solid spines near the top, the secondary valve mostly conical with flattened apex, smooth or rarely with two larger spines near the margin or at the margin and then adherent to the hoop of the mother-cell.

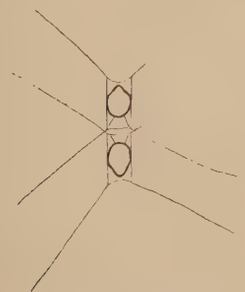

Fig. 23. *Chætoceras ceratosporum* Ostf.? from Iceland (drawing by Dr. O. Paulsen).

Geogr. area: widely distributed in the Baltic and adjacent waters from the Aaland Islands to Kristianiafjord [Cleve, Gran, Levander, Apstein, Lohmann, Ostenfeld]; ? English Channel [Mangin]; ? North Sea and West-coast of Norway.

The resting spores of this species (see Figs. 19– 20) are so characteristic that it is easily recognised when they are present; but when not present, it is difficult so separate it from *C. gracile* and *C. septentrionale* as the vegetative cells stand nearly intermediate with regard to characters between these two species, perhaps nearer to *C. septentrionale*. From that and from its occurrence in the Baltic it is easily understood that Apstein (l. c.) has taken it for *C. gracile*, as he has not seen the resting spores.

I have found it several times in the Danish waters: in the Belt Sea off Lyø in March 1901 (Fig. 20), in the Baltic off Rødvig in April 1904, March 1905, and January to April 1906 (Fig. 19). Further I have

seen it in a plankton sample from off the Aaland Islands kindly sent me by Dr. K. M. Levander of Helsingfors (Fig. 21). Apstein (l. c.) reports it from May 1904, February, May and August 1907 in the Baltic[1] and gives figures of it (Fig. 22).

I think that also the records of *C. gracile* by Cleve from the Swedish west coast and by Gran from the Kristiania Fjord belong to our species. Perhaps we further may add the records of *C. gracile* from the Norwegian Sea (Febr. 03), the North Sea off Holland (Nov. 04), the English Channel (Febr. 03, Aug. and Nov. 05)[2], assuming that *C. tortilisetum* Mangin from the Channel (St.-Vaast-la-Hougue 1909) is also the same. We then get an area reaching from the inner part of the Baltic along the coasts of West Europe to West Norway in North and the English Channel in South.

The species has its flowering time in the spring and seems to be a northern neritic species. In good agreement with this I have got from dr. Paulsen a drawing (Fig. 23) of a very similiar or identical form found in the coastal water of Iceland.

6. Chætoceras Vistulae Apstein, Wissensch. Meeresunters., Abt. Kiel, N. F., Bd. 11, 1909, p. 136, fig. 2.

Fig. 24. *Chætoceras Vistulæ* Apstein, from the mouth of the river Weichsel. ($^{400}/_{1}$)

Cells solitary or two together, 7—8μ broad, longer than broad; valves in side view very concave, in valvar view narrow-elliptic; setæ emerging from the prominent corners, nearly straight, forming a very acute angle with the longitudinal axis of the cell; chromatophore one, in front; resting spores unknown.

Geogr. area: Neufahrwasser near Danzig in the mouth of the river Weichsel [Apstein, Aug. 1904 and 1906].

This species is very different from the other solitary species and is easily recognisable.

Apstein (l. c.) does not decide if it is a brackwater or a freshwater species, but it has been found in brackish water and therefore I have chosen to take it along with the other marine species. My drawings (Fig. 24) are from material kindly sent me by Professor Apstein and show how the cell-division proceeds. —

The revision given here of the section *Simplicia* of *Chætoceras* is far from being the final arrangement of these small and intricate species, but I hope it may be of use for further investigations.

Finally I add a key for a preliminary identification of the species hitherto found in the sea.

Key to the marine species of Chætoceras, sect. Simplicia.

A. Valves in side view not concave; proximal part of the seta nearly perpendicular upon the valve, not distinctly curved.
  a. Distal part of the seta clavate . . . . . *C. distinguendum* Lemm.
  b. Distal part of the seta not clavate . . . . . *C. simplex* Ostf.

B. Valves in side view concave; proximal part of the seta not perpendicular upon the valve.
  a. Proximal part of the seta distinctly curved, distal part diverging at about a right angle from the longitudinal axis of the cell.

[1] When Apstein in a note says that two records of it in "Catalogue des espèces de plancton etc." (Public. de circonstance No. 33, 1906) are "irrtümlich", he should have sought for them in the "Bulletins"; he would then have found the record.: Febr. 1903 Manche E. Stat. 19, and further the name in the Norwegian list from Febr. 1903 where it must have been indicated in spite of the symbol for frequency having fallen out.

[2] All from the International Investigations of the Sea (Catalogues des espèces de plancton, etc. 1906, 1909).

a. Distal part of the seta nearly straight; resting spore with numerous small spines on both valves	*C. gracile* Schütt.
β. Distal part of the seta twisted or coiled; cell mostly longer than broad; resting spore unknown	*C. septentrionale* Östr.
γ. Distal part of the seta nearly straight or in smaller specimens twisted; resting spores with two large hollow spines on the primary valve and also often with small spines, secondary valve smooth or rarely with two large spines	*C. ceratosporum* Ostf.
b. The whole seta nearly straight, diverging at a very acute angle from the longitudinal axis of the cell	*C. Vistulae* Apstein.

April 1912.

MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER
SERIE: PLANKTON · BIND I · NR. 11 · 1912

A NEW APPARATUS

FOR

MEASURING THE VOLUME OF PLANKTON SAMPLES BY DISPLACEMENT

BY

J. P. JACOBSEN AND OVE PAULSEN

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1912

THE volume of a plankton sample is generally measured by deposition: the plankton sinks to the bottom of the bottle wherein it is held, and in the course of some time (a week generally in Denmark) it shrinks, especially when often lightly shaken, to a smaller volume than it had at first. The bottle is then marked outside in the height of the plankton surface, emptied and the volume of water which fills it up to the mark is measured by means of a burette. This method gives relative values of the volumes of the different samples, but the absolute values are certainly to high, especially when long-

ıratus is well known
ıs however its short-
ıtula, a very difficult
n whose movements
: is besides difficult

CORRECTIONS

.cobsen to construct
This was followed
th in the series. A

P. 3 line 6 from above: to should be too.
- 4 - 5 — — : vas — - was.
- 4 - 7 from below: negligeable — - négligeable.
- 6 in the explanation of fig. 2: fed should be fat.

front and a part of
ette (*d*) divided into
the burette can be
below with one of
). The glass funnel
the tube to the stop-
ed obliquely and its
glass-cover (*h*) laid
); the walls of the

glass funnel must be fairly thick (e. g. 3 mm.). By means of a spring (*k*) the ground glass-cover is pressed against the rim of the glass funnel. As seen in the figure the indications on the burette (*d*) begin at 0 and the volume of the burette, reckoned from 0 up to the upper stop-cock (*c*), is equal to the volume of the glass funnel (*g*) reckoned from the stop-cock (*f*) to the spout (*i*), when the glass cover is lying on the funnel. With a suitable position of the taps and on sucking at *a* we are now able to get the burette and its spherical dilatation near *c* filled with liquid, if the glass funnel is constantly kept full. This being done the tap (*f*) is turned half round; the flow is now stopped and the liquid cannot run back; we are now able to make the liquid which is in the glass funnel run down into a glass placed under the tube *e*. The apparatus is now arranged so that the 0 point of the burette lies higher than the spout (*i*) of the glass funnel; if therefore the glass cover is laid over the funnel and the tubes *f* and *c* placed so that the

amount of liquid found between them is able to flow up into the funnel, whilst the air enters through the tube *b*, the funnel will gradually be filled and if the apparatus is adjusted, the liquid will reach the extreme part of the spout *i* at the same time as the surface in the burette is at 0. In this case it is evident that if a body, the volume of which is v cc., had previously been placed in the funnel the liquid would just reach the extreme spout when the surface in the burette vas at v. If the body placed into the funnel is a filter containing the quantity of plankton that has to be measured we are in this way able to obtain a determination of the volume of the filter and the quantity of plankton together; if we take the filter alone without the plankton we obtain a determination of its volume which may be used for the determination of the volume of the plankton. The same filter may generally be used for all the determinations of volume, so that the volume of the filter can be determined once and for all; it is advisable however, to make several determinations of the volume of the filter and take the average; it should be observed, that if the apparatus has a zero error this enters into the determination of the volume of the filter and the volume of filter + plankton and is consequently eliminated on taking the difference of the volumes; we can therefore consider the observed volume of the filter as being correct even though it has been determined with a zero error. As to the manner of proceeding on filling and emptying the glass funnel when the filter and plankton are placed in it, we may remark further, that the liquid must be run in slowly, otherwise the plankton especially during the filling process may be stirred up in the liquid and carried over the rim of the filter, a difficulty which is avoided when the glass funnel is not filled too quickly. On filling and when the glass cover is taken off, we must make certain that there are no air-bubbles in the plankton mass or behind the filter, which have not been driven out by the rising liquid; they are generally got rid of by means of a dissecting needle. In order to make the glass cover close tightly to the rim of the glass funnel it is advisable to rub the latter with a little vaseline or grease but only in very inconsiderable quantities, so that it does not in any way influence the position of the glass cover in relation to the glass funnel. The liquid used for filling the apparatus may be either water or alcohol but the latter is preferable because it drives out the air better.

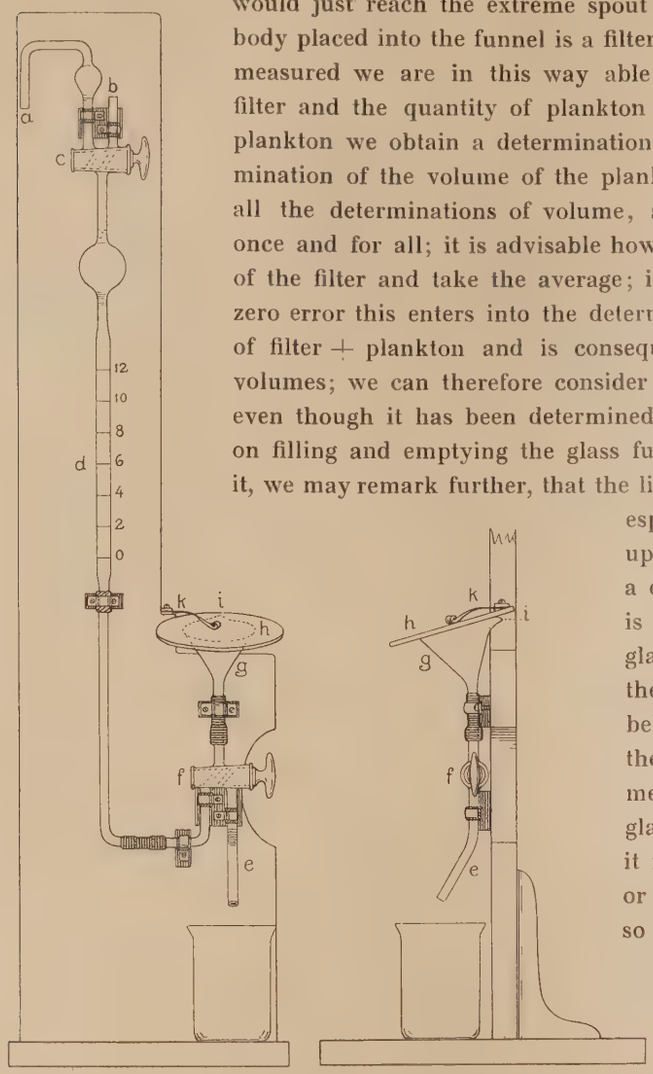

Fig. A Fig. B

Fig. 1.

The worst source of error is here, as in Apstein's apparatus, the amount of water held back in the plankton when brought into the funnel. For small plankton samples it is only a "quantité negligeable" but for greater ones it is a serious shortcoming. The manner of proceeding has been to press the plankton, whilst lying in the filter, lightly in a dish-cloth and in this way to suck out the surplus of water before the filter and the plankton was put into the funnel. All analyses were repeated and each time the filter with the plankton was taken out and pressed in the cloth. As a matter of fact small samples have always given the same result when measured again, but in bigger ones the result depends upon the amount of water sucked out of the plankton before the measurement. Thus in a sample from Anholt the volumes obtained varied between 3·7 and 2·4 cc. This relatively big sample was however

one of the first analyzed and as more practice in dealing with the apparatus was gradually obtained such large deviations did nor occur again. The most important thing is of course to press out as much water as possible without totally drying up the plankton or the outermost parts of it.

By means of the new apparatus Paulsen has made analyses of two series of plankton samples from the light-ships Horns Reef and Anholt Knob. The samples were taken fortnightly in the year 1910 with a medium-sized Apstein net (gauze 20, diameter of the opening 16 cm) in vertical hauls, at Anholt Knob in a depth of 26—0 m, at Horns Reef 28—0 m.

The results obtained are seen from the following table together with the results of measurements by deposition given for comparison.

Anholt Knob			Horns Reef		
	Volume in cc. by		Volume in cc. by		
Date	Displacement	Deposition	Displacement	Deposition	Date
1·1		1·4	0·5		1·1
15·1	0·7	3·0			15·1
1·2	0·6	3·3	0·3	0·5	3·2
17·2	0·7	5·5	0·3	0·5	14·2
1·3	0·8	6·5	0·4	0·9	3·3
15·3	2·3	29·5	0·4	1·4	14·3
1·4	1·3	13·4	0·8	2·5	4·4
15·4	2·4	33·5	1·0	9·6	14·4
1·5	1·2	8·5	0·3	0·5	2·5
15·5	1·3	7·2	0·1	0·5	16·5
1·6	1·2	6·9	0·3	0·5	2·6
15·6	1·4	6·8	1·0	5·9	16·6
1·7	1·3	7·5	0·8	6·4	4·7
15·7	1·7	11·5	0·5	5·8	14·7
1·8	1·3	9·3	0·5	3·5	1·8
15·8	1·1	4·4	1·6	7·0	15·8
1·9	0·9	11·5	0·3	1·4	1·9
17·9	1·0	9·0	1·4	5·0	15·9
2·10	2·0	20·2	1·0	5·0	3·10
15·10	1·0	10·2	0·5	3·0	17·10
2·11	1·2	18·2	0·2	0·5	3·11
15·11	0·2	1·8	1·5	6·1	17·11
1·12	0·9	8·5	0·7	1·3	1·12
14·12	0·7	2·7	0·2	0·5	15·12

The annexed curves give a graphic view of these numbers. In both figures the lowest curve represents the values found by measuring the plankton in the apparatus, and the dotted curve represents these values tenfold magnified. It is seen that the latter mostly comes near to the third curve representing the values found by deposition. These values are thus very exaggerated, but not to the same extent in all cases: for great volumes the exaggeration is greater than for smaller ones and the exaggeration seems specially great where the maximum is due to long-horned diatoms (e. g. Anholt Knob 15 III, 15 IV, 2 XI). On the other hand, two different maxima of Rhizosolenia alata at Anholt (15 VII, 2 X) show a much smaller exaggeration i. e. less than tenfold. As to Horns Reef it is seen that maxima and minima alternate in a very irregular way and conditions here are not clear. At Anholt Knob there are two distinct diatom-maxima, in spring and in autumn, but no distinct maximum seems to be effected by the other classes

of organisms. Details of all the samples dealt with here will be published in the "Bulletin planktonique", to which the reader is referred for further information.

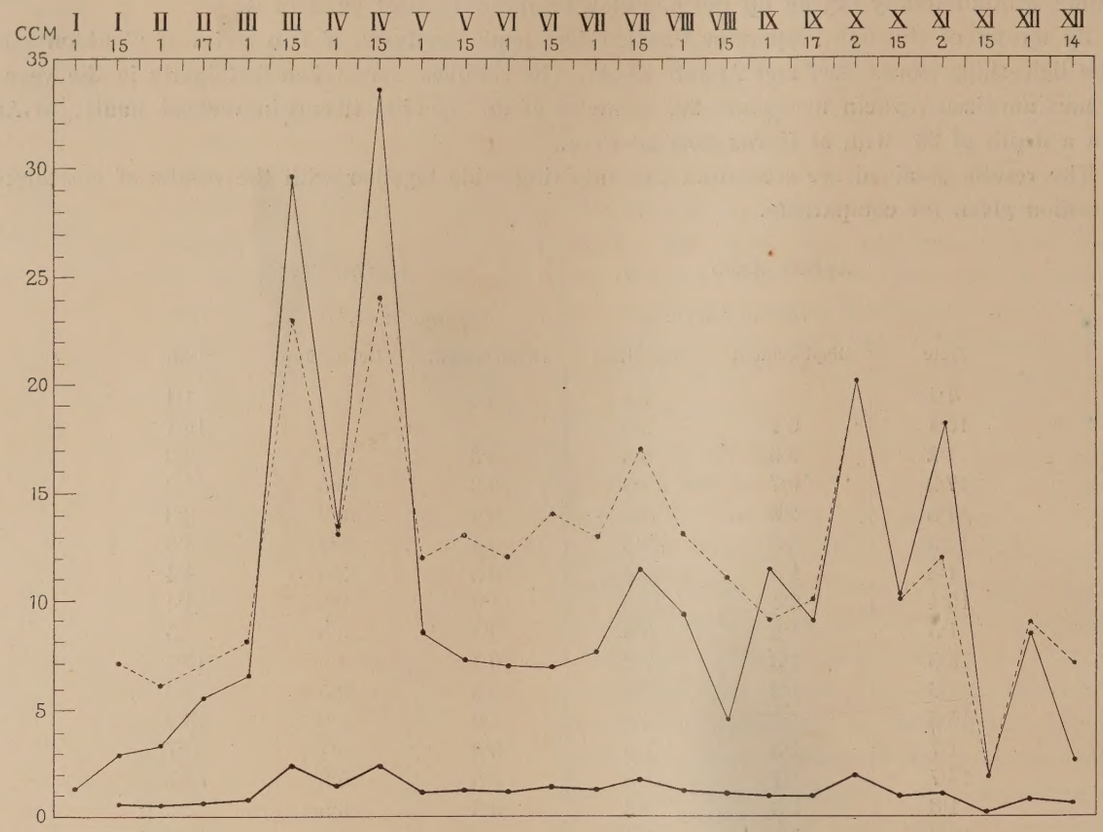

Fig. 2. Plankton volumes from Anholt Knob 1910.
The lower fed curve shows the volumes obtained by measurement with the apparatus, the dotted curve the same volumes tenfold magnified. The thin curve shows the volumes obtained by deposition.

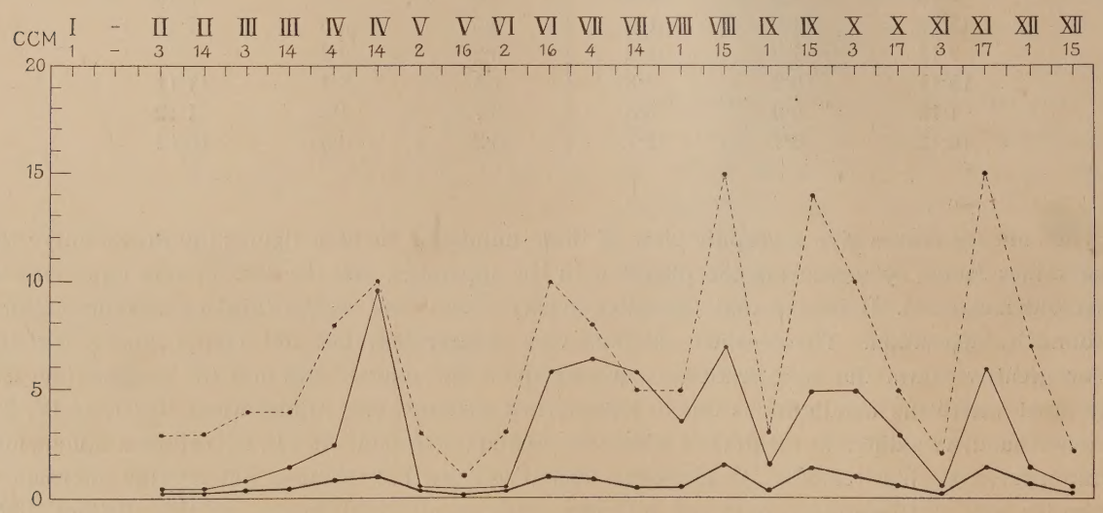

Fig. 3. Plankton volumes from Horns Reef 1910. For Explanation of the curves see Fig. 2.

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